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NOTICE TO SUBSCRIBERS.

Hereafter we shall follow the general rule regarding subscriptions, and shall continue sending THE TECHNIC to subscribers until notified to discontinue.

WE have the pleasure of presenting this month an address delivered by Professor Howe upon the "Stone Arch" before the Engineering Club of St. Louis and read in part before the student body. The article traces the history of the stone arch from its earliest form known to archaeology as used over door ways, to the magnificent bridge structures of to-day. A short sketch of each bridge is given presenting the important features of its construction. The illustrations represent a number of the more important bridges and the various types of arches as used in arched structures, several of which appear for the first time in print. These views are taken from the collection of photographs which Professor Howe has spent several years in gathering for the Civil Engineering Department. His collection already numbers several hundred, representing the most noted bridges of the world both from the historical and engineering point of view. To this collection has just been added a copy of the Cornell University collection which is very complete in itself. This makes one of the most complete as well as valuable collections of photographs of bridges in the possession of any school, and the Institute is justly grateful to Professor Howe for his interest and energy in bringing together so complete a set of photographs.

AT the beginning of the year THE TECHNIC predicted a bright prospect for the Scientific Society, but before the year is half over THE TECHNIC must endeavor to find a reason for its miscalculation. The truth of the matter is that the Scientific Society is on the verge of a decline unless some new stimulus presents itself. The blame can not be laid to the Faculty for they gave the Society two hours per month taken out of Institute time. The Society administration declines the responsibility for they have provided for two meetings a month instead of one as heretofore. Six papers have been presented and as many more are ready for presentation and others promised. The trouble appears to be with the membership in general.

It would be worth while to note that with one exception all of the papers presented this year have been prepared by Juniors. Very little discussion has been indulged in. In fact the only action in which the Society seemed to be firmly united was a bolt for the door the instant the speaker turned his last page, and without any form of adjournment. Next term the Society will meet in the evening, and now let every man in the Institute lend his co-operation and make the Scientific Society, what it should be; the most prominent of the student organizations as well as one of the most valuable.

ONE of the most prominent and admirable features of the course of instruction in the Institute is the individual work, that is, the plan of work in the shop laboratories and drawing rooms, so far as possible is arranged so each student may individually carry on his work and not be held by class instruction. Of course, class work is provided and carried out, but the student is given full opportunity to work as his own ability will let him. He is not held back if he is ambitious and able to advance but is urged to force ahead. At the same time the man who is less ambitious is required to complete the full amount of work as laid down in the curriculum in order to remain with the class. In this way the man who is ambitious is able to obtain a great deal more from the course than would be the case if only class instruction ware given. This plan of work has been adopted not only in the shop and laboratories but in the drawing department as far as is possible—where each one is given the opportunity to do as much as he can consistently with accuracy and thoroughness. Where it has been necessary to depart from this rule, it was thought to be more advantageous to the individual to do the work as a class or unit rather than alone. In the shop the work is entirely carried on by the individual, each being given the work that particularly suits his needs. In the laboratories the same rule applies. There it is not possible for the class to work as a unit, but each man must work alone advancing as rapidly as is possible according to his application and ability. With this plan of work the loss of time from a department means only a loss of time from the individual work. Time so lost can in general be made up during the hours when another class is in the department or the department is open, as the student can go on where he left off without further direction. In the Free-hand Drawing room, while pencil, crayon, pen and brush work is being carried on this is not so easily arranged and carried out, another obstacle presents itself which differs materially from the requirements of other departments. This arises from the fact that both sections of the Freshman class use the same casts and models.

In outline work each man must complete his drawing from the subject, in the same position and point of view as he commenced. In work in light and shade another element arises, that of direction of light. Thus students coming in from one section to another would find it almost impossible to obtain the same conditions of light and position as he had during regular hours. If the subject is in use, as it is most likely to be, then he must take another model and thus interrupt his regular work

In giving special instruction the time and attention of the instructor is required just at the moment when he is not at leisure to give the time, as the first part of the hour is always more fully occupied than the latter. This is often occupied with special exercises in sketching, group drawing and talks on general topics. Irregular students thus have to delay until these directions are over, losing a good part of their time.

These objections to the plan of making up time lost in one section during the time of another section only applies when the work is from models. When the drawing is mechanical the case becomes different, each student has his own work independent of any one else or his position in the room and the work can be taken up immediately where left off. After considering this it has been deemed best by the heads of the department to forbid, time lost from free-hand drawing being made up during the time another section is at work. These reasons present sufficient grounds for the action taken by the Instructor in Drawing, in order to give his full time to the class in charge, and he is fully justified in making the matter a personal one as the opportunity to make up lost time thus becomes a private lesson or coaching and should be under the same condition as outside instruction.

HISTORY OF THE STONE ARCH.*

PROFESSOR MALVERD A. HOWE.

THE history of the development of the masonry arch is very interesting as well as valuable. It is interesting because its origin is more or less uncertain, and there is always a chance for learning something new concerning it. Within the past two years the date of the construction of the first masonry arch, in the form common at the present time, has been carried back over three thousand years. It is valuable in furnishing engineers and architects with a large number of examples from which to select such features as are considered to be good and to profit by avoiding the errors made by their predecessors.

As late as 1840 little or nothing was known about the theoretical principles of the arch, so that all designs were necessarily modifications of previous designs or purely experimental. This fact is well illustrated in the Pont-y-Prydd which will be described later.

In tracing the development of the arch only its application in the construction of bridges will be considered in general.

The Century Dictionary defines the word "arch" in the connection with architecture, as a "structure built of separate and inelastic blocks, assembled in such a way as to retain their position when the structure is supported extraneously only at its extremities."

According to this definition the arch must be very rare. In fact, it is doubtful whether it exists, as, up to the present day, physicists have been unable to find any inelastic substance from which to cut blocks.

Professor Greene, in his text-book entitled "Trusses and Arches," defines an arch as follows: "An arch may be considered to be any structure which, under the action of vertical forces, exerts horizontal or inclined forces against its supports or abutments."

It is to be noted that the particular form of the structure is not specified; and this is right, since, even in masonry structures where the true arch is employed, we have many different forms.

The primitive form of the arch was probably used over door ways or entrances in the form of two slabs of stone strutted against each other as the rafters in the modern roof. The earliest example of this form, of which we have any definite information, is that over the entrance to the great pyramid of Gizeh, constructed by Khufu some time between 4235 and 3124 B. C. (The illustration indicates that this is a true arch). (Fig. 1).

Tuckerman, in his "Short History of Architecture," states that some of the chambers in this pyramid are roofed with slabs of stone inclined like rafters. The Encyclopædia Britannica makes no mention of this, but states that the third pyramid contains a chamber ceiled with a pointed arch, adding that this is not a true arch, the stones being merely strutted against each other, as over the entrance to the great pyramid, and that the under side is cut to the form of a pointed arch. In a small sketch, (Fig. a) the Encyclopædia gives a cross-section of the vaulted chamber where the roof-stones are shown extending quite a distance into the masonry back of the side walls.

* From a paper read before the Engineers' Club of St. Louis, Mo., and published in the *Journal of the Association of Engineering Societies*, February, 1898.

If such is actually the condition, the roof is not a true arch, but an arched roof.

Crude arches of brick were found in the ruins of Thebes, which were probably built as early as 2900 B. C.

Beneath the palaces of Nimrod (about 19 miles below Nineveh on the left bank of the Tigris river,) the ancient Calah, founded 1300 B. C., sewers were found covered with pointed arches of brick.

These arches, contrary to the usual form of to-day, were inclined and could have been con-

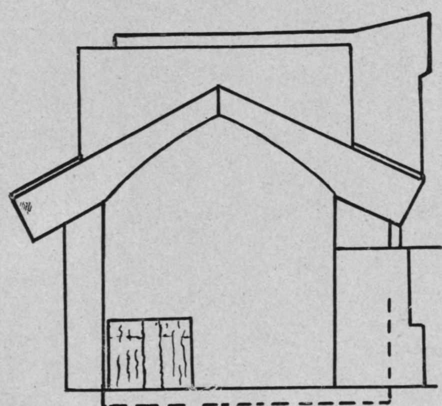


Fig. *a*.

structed without the use of a form for their support during construction.

The gates to an ancient city in Assyria, now represented by the ruins of Khorsabad, were arched with semi-circular voussoir arches of stone, having spans of from 12 to 15 feet. These are supposed to date as early as the time of Sargon, who founded the city about 722–05 B. C.

One of the most important of the ancient structures in connection with the history of the stone arch, is Campbell's Tomb of Gizeh, supposed to have been built 600 B. C. "It is an open excavation, 53 feet 6 inches deep, 30 feet by 26 feet 3 inches on plan, with nitches, etc., leading out of it. This excavation is supposed, from some indications left of a springing stone, to have been covered by an arch. If so, this would be the oldest known stone arch of a large size. In fact, it is difficult to imagine any other way in which this large excavation could have been covered."

But more interesting and important than this was the tomb, built of good masonry, which was found in the center of "the excavation." (Fig. b) The roof was formed of three stones making a true arch, over which was a perfectly formed voussoired arch of four distinct rings, the inner ring having a span of about 11 feet. These arches were nearly if not quite semi-circular.

At about this time the Romans commenced the use of the voussoired arch, as witnessed by the

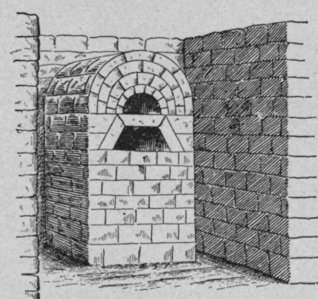


Fig. *b*.

outlet of the Cloaca Maxima, supposed to have been built 615 B. C. (Fig. 3). The arch consists of three concentric rings of voussoirs, the inner ring having a span of about 14 feet.

Until quite recently all records in the form of ruins, tablets, etc., failed to indicate that the true arch was employed in structures to any great extent prior to the 6th century B. C. The arched form, however, was quite common from earliest times, and ruins have been found in all portions of the world. Since 1894 a voussoir arch built of mud brick (Fig. 35) has been discovered in the excavations at Nippur, an ancient city which existed south of Babylon. A very conservative estimate places the time of the construction of this arch at 4000 B. C.

One of the best examples of the false arch exists in Greece. It was built probably as early as 1000 B. C. This is the Treasury of Atreus at

Mycenae, which consists of two underground chambers, one much larger than the other. The larger chamber is circular, and is entered by a huge door way at the end of a long avenue. (Fig. 2.)

The internal form is that of an immense lime kiln. The masonry consists of horizontal projecting courses of stone, the inner projecting corners being cut off. (Fig. c.)

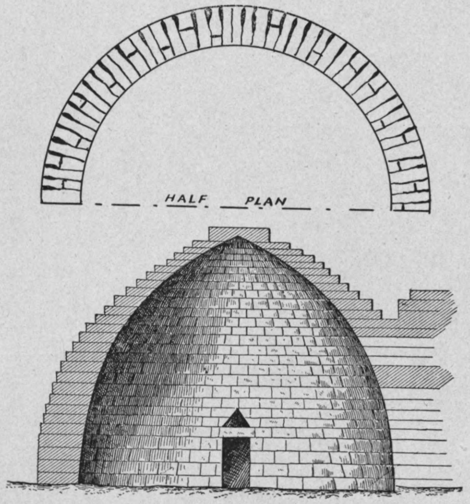


Fig c.

The arched form does not prove that the builder was familiar with the true arch. But the manner in which the horizontal courses are constructed clearly indicates that he had some idea of the true arch; as either each stone is cut wedge-shaped, like voussoirs in a vertical arch or the joints are tightly wedged with small stone. The internal diameter of the chamber at the base is 48 feet 6 inches, and the clear height 45 feet.

In Asia Minor tombs were found having arched roofs made by corbelling out horizontal courses of stone until they meet at the top, and then cutting off the projecting edges underneath. Lübke, in his "History of Architecture," states that these were probably constructed as early as 700 B. C.

The arch was first used by the Romans for the construction of stone bridges in the 2nd century B. C., though stone was probably employed for this purpose much earlier. The early stone bridges were constructed by building piers in the stream so close together that the opening could be spanned by stone beams. Fig. 4 shows this style of construction. The bridge over the Euphrates river at Babylon was probably built in this manner.

There are a large number of examples of the true arch in bridge construction in China, as well as the primitive form of stone bridges without arches. The date at which these bridges were constructed is unknown, but many believe that the Chinese built the true arch long before it was known to the western world.

There is an account of a bridge over a river named Laffranyi, China, connecting two mountains. The bridge is said to be of one arch of stone having a span of 600 feet and a height of 750 feet. (Edinburg Encyclopædia.) The authority for this account is not authentic, and, although a stone bridge of such magnitude is not impossible, from the engineer's point of view it is improbable.

The old voussoired arch bridges of the Chinese are interesting from the peculiarity of the arch ring. "Each stone, from 5 to 10 feet in length, is cut so as to form the segment of the arch, and in such cases there is no key stone; ribs of wood fitted to the convexity of the arch are bolted through the stones by iron bars fixed into the solid part of the bridge; sometimes they are without wood, and the curved stones mortised into long transverse blocks of stone."

The details of the more modern Chinese arches do not differ essentially from those employed in other countries. (Fig. 12.)

To the Romans we are indebted for the almost universal use of the voussoired semi-circular arch in bridge construction. From the 2nd century B. C. until the 4th century A. D., the Romans built many magnificent stone arch bridges for roads and aqueducts, the magnitude of which has not since been equalled. It would take too much time to enumerate the many bridges in Rome and in the conquered provinces, which were constructed by the Romans and of which we have either authentic details, or the structure itself, so we will mention only a few of the most important structures.

In the city of Rome and in the immediate vicinity were constructed aqueduct bridges containing immense amounts of masonry, and throughout these the voussoir arch was employed.

The following table gives, in the chronological order of their construction, the number of miles of arches used in supporting aqueducts. (Mr. F. W. Blackford in *Journal of the Association of Engineering Societies*, December, 1896).

NAME.	DATE.	Total Length in Miles	Length of Arches in miles.
	B. C.		
Appia	312	11	Little
Anio Vetus	272–264	43	"
Marcia	145	61	12
Herculea Branch		3	
Tepula	126	13	Little
Julia	34	15	6
Virgo	21	14	Little
	A. D.		
Alsientina	10	22	Little
Augusta	10	6	"
Claudia	50	46	10
Anio Novus	52	58	9
Neronian Branch	97	2	2
Triana	109	42	Little
*Hadriana	117	15	7
Sabina Augusta	130	15	Little
Aurelia	162	16	7 (?)
Severiana	200	10	Unknown
Antonia Branch	215	3	3
†Alexandrina	226	15	7
Totals		410	63

Remarks: *Restored 1585-1590. †On arches of Hadrian.

From this it is seen that between 312 B. C., and 226 A. D., sixty-three miles of arched bridges were built.

Pont du Gard, (Fig. 11) near Nimes, France, was built by the Romans during the reign of Augustus (27 B. C.–14 A. D.) under the direction of Agrippa. This is an aqueduct bridge composed of three tiers of arches. The lower tier containing six arches. The maximum span is 80 feet 5 inches. Each arch is made up of four separate rings, side by side and not bonded together. The platform of this tier is 20 feet 9 inches wide. The second tier contains twelve arches of about the same span as those in the lower tier, but has only three rings side by side and is but 15 feet wide. The upper tier contains thirty-six arches, each having a span of 15 feet 9 inches, and is 11 feet 9 inches on top. The aqueduct channel is about 4 feet 9 inches deep and 4 feet wide. At the beginning of the 5th century the ends were destroyed by barbarians. In 1743 the bridge was repaired, and the lower tier widened to carry a highway. The maximum height of the bridge above the river Gardon, which it crosses, is 160 feet.

Emperor Augustus constructed a beautiful stone bridge over the river Marecchia, at Rimini, Italy. (Fig. 5.) It consists of five semi-circular arches having a span of 23 feet. This bridge is in use at the present day, and from all appearances has required but few repairs.

The most magnificent bridge built by the Romans was constructed in the reign of Augustus near Narni, Italy. It consisted of four arches having spans of 75, 135, 114 and 142 feet respectively.

About 104 A.D., during the reign of Trajan, the aqueduct bridge at Segovia, Spain, was built. The bridge contains 109 arches in two tiers. Thirty of the arches are modern, but similar to the old ones. The length of the bridge is over 2,500 feet. The three center arches are 102 feet high. The entire structure is built of squared granite blocks without mortar. (Fig. 9.) During this same period, Trajan constructed a fine stone bridge over the Tagus river at Alcantara, Spain. (Fig 6.) There were six semi-circular arches of various spans, the maximum being about 100 feet. The total length of the bridge was 670 feet, and the maximum height above the river was 210 feet. The material was granite, laid without mortar. The bridge was in use until 1809, when the English destroyed the second arch on the right bank of the river. This was temporarily repaired, but again destroyed in 1836, since then no repairs have been made, the natives using a ferry boat to cross the stream.

In 135 A.D., during the reign of Hadrian, the bridge now called St. Angelo was built at Rome. (Fig. 20.) It consists of four circular arches, the span of the largest being 62 feet 4 inches. This structure is supposed to have been covered with a roof of bronze supported by 42 columns. It was repaired by Popes Nicholas III and Clement IX.

The present balustrade, statues, etc., are of course recent, but the arches are old. In nearly all of the Roman bridges the arch was semi-circular in form, and although the segmental and pointed forms may have been known, they were never employed in the construction of bridges. The spans of the arches were usually small in comparison with a few of our modern structures, yet they successfully built bridges with spans of 142 feet, which is exceeded by but a small percentage of the structures built since the 17th century.

Another interesting fact in connection with the Roman bridges is that the centering was almost always supported upon large stones projecting from the piers below the springing line. These are clearly shown in photographs of the Pont du Gard and the aqueduct bridge near Segovia.

We come now to a period of several centuries in which little was done in bridge building or in keeping in repair the bridges already erected, though we may mention two bridges constructed by the Moors in Spain. At Cordova, about 912–916 (?) was built a bridge of 16 arches over the Guadalquiver. The style is a combination of the Roman and Moorish types.

In 997 at Toledo, Spain, the bridge Alcantara was built over the Tagus river. (Fig. 7.) It consists of practically two spans, the larger being 93 feet. The style of the structure is Roman and Moorish; the arches are semi-circular while the tower has the stamp of Moorish origin.

In the 12th century the art of bridge building was revived.

Owing to the destruction of many of the old Roman bridges and the unsettled condition of many districts, there was little "security for travellers, particularly in passing rivers, where violent exactions were made by banditti." "To put a stop to these disorders, sundry persons formed themselves into fraternities, which became a religious order, under the title of 'Brothers of the Bridge.' The object of this institution was to build bridges, ferry boats and receive travellers in the hospitals on the shores of rivers."

The first established was upon the Durance, at a dangerous place named Maupas; but in consequence of the accommodations arising from the establishment, the same place acquired the name of Bonpas. St. Benezet, who proposed and directed the building of the bridge of Avignon, was a shepherd, and was not twelve years of age when he proclaimed he had received revelations from heaven commanding him to quit his flock and undertake this enterprise. He arrived at Avignon just at the time when the Bishop was preaching to fortify the minds of the people against an eclipse of the sun, which was to happen upon that day. Benezet raised his voice in the church and said that he had come to build a bridge. His proposition was accepted by the people with applause, but rejected with contempt by the magistrates and by those who thought themselves wisest. As it was at this time an act of piety to build bridges, and Avignon being then a popular republic, the people prevailed, and every one contributed to the good work; some by money and some by labor, all under the direction of Benezet, aided by the Brothers. St. Benezet, by performing a great number of miracles, animated the zeal of everybody. Upon the third pier was erected a chapel to St. Nicholas, protector of those who navigate rivers. This was done, however, after the death of St. Benezet, which happened in 1184. (Edin. Ency.)

This bridge, (Fig. 10) which was composed of 18 or 21 arches, was begun in 1176 and completed in 1188. In 1385 Pope Boniface IX destroyed some of the arches. In 1410 the inhabitants blew up a tower causing the fall of three spans. In 1670 the cold was so severe, that the Rhone for several weeks bore the heaviest carriages; when the thaw followed the ice destroyed the piers, but the third pier with the chapel of St. Nicholas has remained, notwithstanding these many accidents. The span of the largest arch was about 102.9 feet and was semi-circular. (Authorities differ here, some claiming that the arch had a span of 110 feet and was segmental. The Encyclopædia Britannica states that the arches were elliptical, the minimum radius of curvature being at the crown.)

In 1176, or practically at the time when the bridge at Avignon was commenced, Peter of Colchester, a priest, began the erection of the old London bridge across the Thames, but the structure was not completed until 1209. The bridge originally contained 19 pointed arches having spans from 9 to 20 feet, and piers 25 to 34 feet thick.

For many years there were houses along each side, but these were removed in 1758, and the middle pier and two arches replaced by a single arch of 72 feet span. In 1824–31, the new London bridge replaced this structure.

In 1203, the bridge St. Martin was built over the Tagus river at Toledo, Spain. It consists of five arches, the center arch being the largest, with a span of 132 feet. This arch is very slightly pointed. (Fig. 17.)

In 1281, the Brig O'Balgownie was built over the river Don on the road leading from the old to the new town of Aberdeen, Scotland. (Fig. 8). This bridge contains but one arch, which is pointed and has a span of 66 feet.

These bridges with pointed arches, constructed in different countries, place the introduction of such arches in bridge building at about the 13th century.

The old Charles bridge over the Moldau, Prague, Austria, was built between 1357 and 1507. (Fig. 13). It consisted of 16 spans, the largest being 69.5 feet. In a photograph the arches appear to be semi-circular. The structure was ornamented with thirty statues and groups of saints, one of which is a bronze statue of St. John Nepomac, patron saint of Bohemia, (in whose memory the bridge is visited yearly by thousands of pilgrims.) The saint is said to have been flung from the bridge in 1383 by order of King Wenceslaw, for refusing to betray the confessions of the Queen. The body is said to have floated for some time with five brilliant stars hovering over the head. The bridge was partially destroyed by a flood in 1890.

In 1380 a very large arch was built over the Adda river near Trezzo, Italy, by order of Visconti, but was destroyed by Carmagnola in 1416. From ruins which remained in 1838 (about 20 feet at each abutment) the span has been determined to have been about 251 feet and the rise about 88 feet. The arch ring was remarkable as being in two concentric rings with a total thickness of but four feet.

The Vecchio or Jewelers' bridge at Florence, Italy, (Fig. 14) over the Arno river was first built in 1177, but was rebuilt in 1345. It consists of three arches of 96 feet span and 19.2 feet rise; the curves being segments of a circle and in appearance quite flat. The width of the structure is 105 feet and along the sides are buildings occupied by goldsmiths and jewelers.

Adjacent to the Vecchio bridge, the Trinity bridge was erected in 1566. It consists of three elliptical arches, the largest having a span of 95.8 feet and a rise of 16 feet.

The Rialto at Venice, Italy, built of marble in 1588–91, has but one span of 98.5 feet, with a rise of 23 feet. (Fig. 15). (Fig. 18.)

Apparently in imitation of the Rialto, the Fleischbrücke in Nuremburg was constructed in 1599 with a span of 97 feet and a rise of 13 feet.

These examples of the segmental or elliptical arch mark the advent of flat arches; though, of course, the form was not universally employed, as Pont Neuf over the Seine river, Paris, France, (Fig. 28) built between 1578 and 1604, consists of a large number of nearly semi-circular arches with a maximum span of 51.1 feet and a rise of 21.9 feet.

In 1553–70, the Tempoala aqueduct in the state of Hidalgo, Mexico, was constructed under the direction of a Franciscan friar to carry water to the city Otumba. It contains 68 semi-circular arches, the largest having a span of 58 feet. Its maximum height is 124 feet. It is built on two tangents, 177 degrees apart. The water way is only 8½ inches by 12 inches. (Fig. 19.)

There is a very interesting bit of history in connection with the construction of this aqueduct. "In February, 1553, there was signed a curious contract between the town of Otumba and Zempoala, under the conditions of which the first was to supply priests and friars to minister to the spiritual needs of the second, which in return was to give the water and aid with labor and materials in the construction of the aqueduct which was to carry water to the first city." The contract is still in existence in Mexico and was signed Feb. 7th, 1553. The aqueduct was probably commenced very soon after the signing of the contract, but was not completed without the usual opposition from the narrow-minded and jealous.

The wise ones among the clergy said that it was apparent that the water would be taken from a lower point than it would be carried to, and that the undertaking was too costly and rash to succeed. This claim led to the usual investigation by the authorities, who sent a secret messenger to those higher in authority, and the legend as to the final outcome is thus recorded.

The Friar lived in a hermitage close to the arches in course of construction, where he was ministering to the spiritual needs of the Indians who worked for him. He had for his sole companion a grey cat who brought him every day a rabbit in the rabbit season, and a quail in the quail season. Doubting that this work, so grand and massive, would be able to accomplish the desired result, the "Alcalde" (Magistrate or Judge for the district) made him a visit at the moment when the cat was entering with a rabbit; when the Friar told the cat to bring another for the visitor. The cat started out at once for it, and when he brought it the "Alcalde" was forthwith convinced that the work was in good hands, and would have good results.

The Pont-y-Prydd, over the river Taff, in South Wales, is justly celebrated both on account of its great span and the singular circumstances which attended its construction.

In 1746 William Edwards, a country mason undertook to build a bridge over the Taff. He built one composed of three arches which was well executed. But being in a mountainous district the river became a torrent in a very short time, and in one of these stages about two and one-half years after the completion of the bridge it was swept away.

As Mr. Edwards had given security to maintain the bridge for seven years he immediately set about rebuilding the structure. In order to guard against a future destruction of the bridge by similar torrents he constructed one arch having a clear span of 140 feet and a rise of 35 feet. The arch was completed but the parapets had not been added when the weight of the material in the structure pressed down the haunches, raised up the crown and destroyed the bridge. This was in 1751.

Mr. Edwards was not discouraged and immediately set about building another bridge on practically the same design, but took the precautionary measure of consulting with the eminent engineer Mr. Smeaton. What advice Mr. Smeaton gave is not known but the bridge which was completed in 1755 is standing and is in use at the present time. The spandrels were lightened by three circular openings extending completely through the bridge and the interior filling was composed of charcoal. The span of the present structure is 140 feet and the rise 35 feet. The clear road way is but 11 feet wide, which in consideration of its steepness may explain the existence of the new low level bridge adjacent. One of the most remarkable features in connection with the bridge is that the ring stones are only 30 inches deep on the outside and 18 inches on the interior of the ring. (Fig. 22.)

During the 18th century many fine bridges were built, of these only a few can be mentioned. Near Lisbon, Spain, the Alcantara aqueduct was commenced in 1731 and completed about 1774. It contains 35 pointed arches, the largest arch having a span of 100 feet and a rise of 88 feet. The height of the intrados of the maximum arch is 197 feet, while the maximum height of the bridge is 230 feet.

It is claimed that this is the highest masonry arch bridge, having but one tier of arches, in the world.

Pont-de-la-Concorde, (built 1787) at Paris, France, has five segmental arches, the center span being 102.3 feet with a rise of 9.8 feet.

The Kelso bridge over the Tweed river, Kelso, Scotland, was built 1799–1803. It has five elliptical arches with a maximum span of 73 feet and a rise of 21 feet.

In 1809 the Dunkeld bridge over the Tay river at Dunkeld, Scotland, was completed. (Fig. 16.) There are seven arches, the center span being 90 feet with a rise of 30 feet.

Between 1813 and 1822 a fine bridge over the Garonne river at Bordeaux, France, was built. There are 17 elliptical arches having spans varying from 65.86 feet to 86.92 feet. The maximum span has a rise of 28.9 feet.

The new Waterloo bridge, London, was opened in 1817. (Fig. 21.) There are nine elliptical arches with a span of 120 feet and a rise of 34.6 feet.

The new London bridge was constructed 1824–31. The five elliptical arches have spans varying from 130 to 152 feet. The rise of the maximum span is 29.6 feet above high water. (Fig. 23.)

The Bromielaw bridge in Glasgow, Scotland, (Fig. 24,) has seven segmental arches, the largest having a span of 58.5 feet with a rise of 10.8 feet. It was constructed 1833–36.

In 1841-47, the highest stone bridge in the world was constructed on the canal leading to Marseilles, France, where it crosses the Arc valley. The bridge has three tiers of arches. The lowest tier has twelve arches of 49.2 feet span; the middle tier, fifteen arches of 52.5 feet and the upper tier fifty-three arches of 16.4 feet span.

The bridge is 48 feet wide on top, 1289 feet long and 271 feet high. The width of the canal on the bottom is about 22 feet. (Fig. 29.)

Up to 1847, nothing of any magnitude in the way of stone bridges had been erected in the United States. During this year the Starrucca viaduct*, carrying two tracks of the New York, Lake Erie and Western Railway, over Starrucca Creek near Lanesborough, Pa., was constructed. There are seven segmental arches of 51 feet span, and the maximum height of the rails above water is 110 feet. (Fig. 30.)

*The writer is indebted to Mr. W. L. Derr, Supt. Del. Div. Erie Railroad Co., for a photograph of this structure.

In 1852-59, the Cabin John bridge, the largest stone arch in the world was built, near Washington, D. C., to carry an aqueduct and highway over Rock Creek. Its span is 220 feet with a rise of 57.3 feet. (Fig. 31.)

This magnificent structure derived its name from a mysterious stranger who lived for a time in the vicinity of the small stream which it crosses.

In the year 1825 the following lines were found under an old grain bin in a mill located on the banks of the creek.

> " 'John of the Cabin '—a curious sight
> Sprang out of the river one dark stormy night;
> He built a warm hut in a lonely retreat,
> And lived many years on fishes and meat.
> When the last lone raccoon on the creek he had slain,
> It is said he jumped into the river again.
> As no name to the creek by the ancients was given,
> It was called "Cabin John" after John went to Heaven."

Probably one of the most pleasing stone bridges, from an architectural point of view, is the Echo bridge at Newton Upper Falls, Mass. It has a span of 121 feet and a rise of 42 feet 4 inches. It carries an aqueduct (a portion of the Sudbury River aqueduct for Boston) and highway and was built in 1876. (Fig. 25.)

The Waldi-tobel railway bridge in the western part of Austria, was built in 1884. (Fig. 26.) Its span is 134.5 feet, with a rise of 42.16 feet, while the rails are about 160 feet above the bottom of the gorge which it crosses†.

In 1884 a highway bridge with a span of 150 feet and a rise of 27 feet was built at Elyria, Ohio.

In 1892, at Wheeling, W. Va., an arch with a span of 159 feet and a rise of 28.4 feet was constructed. (Fig. 27.)

In this year the Jaremcze bridge, the largest stone arch bridge in the world for railway purposes, was built in the eastern part of Austria over the river Pruth. (Fig. 32.) The span is 213 feet and the rise 59 feet.

The Cresheim bridge, in Fairmount Park, Philadelphia, Pa., built in 1892 has a span of 116

†The writer is able to illustrate the Waldi-tobel and Jaremcze bridges through the courtesy of Mr. Ludwig Huss, Ch. Engr. of the Austrian State Railways.

feet with a rise of 21.1 feet. This bridge carries a sewer over a small stream.

The Lodi street bridge at Elyria, Ohio, has a span of 112 feet and a rise of 19.5 feet. It was built in 1894. (Fig. 33.)

During the year 1897 a very artistic highway bridge has been built in Fairmount Park, Philadelphia, Pa. (Fig. 34.) The span is 105 feet with a rise of 11.0 feet.*

The examples of stone arch bridges given above are, of course, but a very small per cent. of those which have been constructed. With but a few exceptions only those structures have been mentioned concerning which the data is believed to be authentic, and of which photographs could be obtained.

*Through the courtesy of Mr John C. Trautwine, Jr., the writer was able to secure a photograph of this bridge.

Data concerning even the more modern structures is very hard to obtain, and in many cases it is practically impossible to purchase photographs.

The following conclusions may be drawn from the above data:

The Romans first used the arch in the construction of bridges in the 2nd century B. C.

Until about the 13th century, the arch in bridges was of a circular form, and almost without exception it was semi-circular.

The pointed arch was first employed in bridges about the 13th century.

In the 14th century, segmental and elliptical arches were introduced.

At the present time the segmental arch is almost universally employed for long spans.

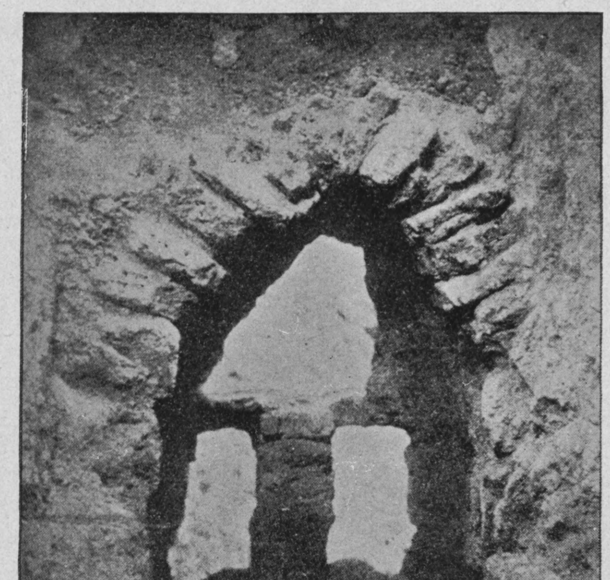


Fig. 35. Mud Brick Arch at Nippur. (4000 B.C.)

The Microstructure of Iron and Steel.

J. J. KESSLER, JR., '97.

THE more thorough and complete the knowledge of the physics and chemistry of any metal or alloy, from the first raw material to the last finished product, the greater will be its value as a material of engineering, and the less will be its cost of production.

Practically none of the industrial metals are used in a pure state. They either contain impurities which were present in the ore, or which were acquired during the process of reduction from the ore. The physical and chemical properties of these metals therefore, are by no means fixed and definite quantities. In the case of an alloy containing two or more metals, each of course contributes its own impurities and adds greater complexity to the structure of the alloy, already perhaps partly chemical combination, partly solution, and partly mechanical mixture.

A small amount of foreign substance may alter profoundly the general properties of the metal or alloy in which it is present. 0.05% Tellurium present in Bismuth renders it minutely crystalline or even entirely obliterates the crystalline structure. 0.2% Zirconium increases the tensile strength of gold about seven times, while the same amount of Potassium reduces it one-half. 0.1% Antimony present in Copper renders it unfit for rolling, while 0.1% Phosporus is enough to make the metal cold short.*

A paper was presented recently before the meeting of an Engineering Society discussing the injurious effects of Bismuth upon brass.† It was stated that a fraction of a per cent. renders the metal hot and cold short. That high brass intended for rolling should not contain over 0.01%, and that brass containing 0.5% Bismuth could not be forged at any heat.

With such radical changes caused by such small quantities of foreign substances, it is small wonder that words like "treachery" and "mystery" have been found necessary by metallurgists who would discuss the erratic behavior of their products, the properties of which they did not possess sufficient knowledge to definitely control.

A block of cast-iron is in many respects quite similar to a composite mineral like granite, in

* Roberts-Austen Journal Soc. and Arts, '98.

† E. S. Berry—Buffalo Meeting, American Institute Mining Engineers '98.

that it is a solid heterogeneous mass, composed of different constituents of different melting points, in fact of entirely different properties throughout; the presence, form and occurence of which depend on the ultimate composition, on the thermal treatment which the mass has undergone and on the work which has been done upon the substance during and after cooling from a molten state. Any given structural equilibrium therefore, is the product of many variables, and any change, even slight, in the relative influence of these variables may produce a great change in the final equilibrium. We may thus find two steels of identical ultimate composition which have quite different physical properties, due to the fact that each has been subject to different heat treatments and to different amounts of work.

H. M. Howe ‡ states with reference to the analogy between alloys and minerals: "The ultimate composition of a crystalline rock may indeed give us a rough idea of its physical properties. * * * * But it is clear that any attempt at an accurate prediction of the physical properties of a crystalline rock from its ultimate composition must be futile. They must either be attained by direct test, or inferred from a study of its proximate composition, which must be determined by whatever means available. * * * * That other and now unguessed conditions profoundly alter both the mineral species and the structure of steel, as of crystalline rock, in most complex ways, is indicated by the utterly anomalous relations between the ultimate composition and the mechanical properties of steel. This anomaly, which has puzzled so many, is readily explained by the close resemblance between the conditions of the formation of rock and of ingot, which not only shows us why we do not discover these relations, but that in all probability *we never can* from ultimate composition. The lithologist who attempted to-day to deduce the mechanical properties of a granite from its ultimate composition would be laughed at. * * * * If these views be correct then, no matter how accurate and extended our knowledge of ultimate composition and how vast the statistics on which our inferences are based, if we attempt to predict mechanical properties from them accurately we become metallurgical 'Wigginses.'"

‡ "Metallurgy of Steel."

Metallurgists are beginning to look upon their products as minerals, and, considered as such, to study their structure. There are two ways in which information may be gained with regard to the structure of a piece of metal. The first is by a study of fractures, which tells something, mainly with regard to the physical properties of the specimen. The second is by preparing an optically smooth surface upon the specimen and differentiating the chemical structural elements by means of suitable etching reagents or even by polishing the specimen until the harder constituents stand in relief as compared with the softer ones. This second method of research has been the means of showing the presence and mode of occurrence of the following structural elements in the different kinds of iron and steel. H. M. Howe has named these substances, giving them the mineralogical suffix, and this generally accepted nomenclature will be used throughout the present paper.

Fig. I. Shows Crystals of Ferrite. (200 Diameters.)

FERRITE—Practically pure iron. It has not been shown whether or not it contains the impurities usually present in iron and steel, but it is iron free from Carbon. It occurs in three distinct forms.

1. When present in considerable quantity, as in

grey cast iron, or in mild steel, slowly cooled or quenched below the critical range, it segregates in large crystalline polyhedric grains which are interfering crystals of the isometric system. Fig. I shows the crystalline grains of Ferrite in a very mild steel. The dark spots show the presence of other segregated substances. The white portion of Fig. II is also Ferrite and it may be seen that even in a steel with considerable Carbon content, (the specimen from which Fig. II was taken contained 0.22% Carbon,) that a considerable portion

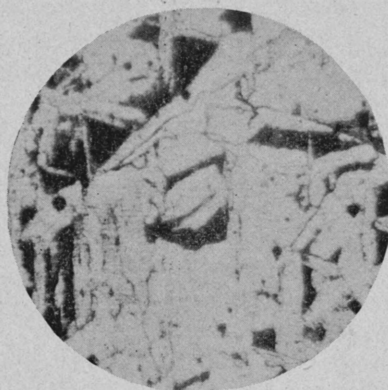


Fig. II. Carbon Steel (0.22%) Annealed and Before Forging. (200 Diameters.)

of this Carbonless iron is present, in part, in all annealed steel where the Combined Carbon is below 0.80%. Although it is a relatively easy matter to distinguish Ferrite on account of the fact that it seldom colors to any great extent under the etching reagent, it is quite difficult to bring out the joints between the grains. This would be impossible if each grain acted toward the etching reagent in exactly the same manner. On account of a slight difference in density, however, as suggested by Osmond, or because the different grains are to a very slight degree chemically different, this is not the case. Either some grains are colored to a slight extent and the others left uncolored, or the reagent attacks some grains more energetically than others, thus rendering the boundary between the parallel, but not connected planes, visible through the microscope.

2. In medium hard steels, slowly cooled, the Ferrite is present in small quantity only, and forms in a network around another constituent, Pearlyte. This is the same form of Ferrite found in the first case, only the granular crystalline structure is absent.

3. Ferrite also exists as a component mineral of the composite structural element Pearlyte, and it will be mentioned later under a description of this substance.

CEMENTITE—This is the Carbide of Iron Fe_3C. It is one of the few structural elements which can be isolated by purely chemical means. Cementite is an extremely hard and brittle substance, consisting generally of silver-lustred, roundish grains seldom over 0.0004 inch (0.01 m.m.) in diameter. It will scratch glass and feldspar, but not quartz (H=6). It is pyrophoric, permanently magnetized by a magnet, unmelted at redness, insoluble in cold dilute acids, attacked with extreme difficulty by copper solutions, but soluble in boiling, moderately concentrated, hydrochloric and sulphuric acids, leaving a slight residue.

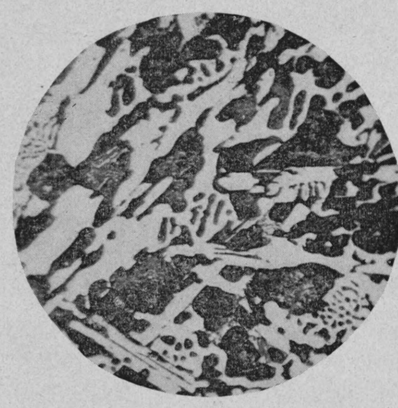


Fig. III. White Cast Iron. (200 Diameters.)

The Carbon present in Cementite has been variously characterized by different authors as "Carbon of Cementation" (Caron), the "Carbon of Annealing" (Osmond and North), and the "Carbon of the Normal Carbide" (Ledebur).

It is in cement steel that Cementite is found in the largest masses and is most easily studied. Fig. III. shows a specimen of chilled cast-iron etched with Iodine, in which the Cementite present is represented in the light part. Cementite is not attacked by Iodine, as shown in the micrograph, and nitric acid colors it only upon prolonged treatment. Cementite is sometimes found as large straight laminæ running parallel to each other; similar groups being bound in a large polygonal network and simple laminæ often curved and interspersed with Ferrite. Cementite is found in all annealed steels, as a component of Pearlyte, if the Carbon content of the steel is below 0.80%, and in a free granular state if the Carbon is above that figure. It is also found in all high Carbon steels which have been hardened.

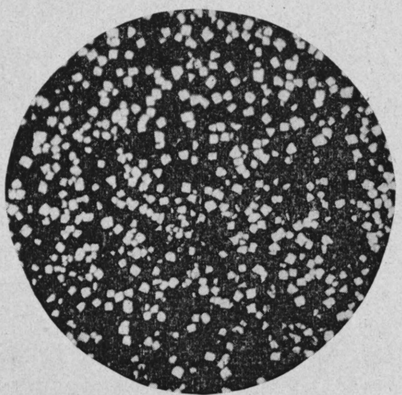


Fig. IV. Antimony, 15%—Tin Alloy, 85%. (40 Diameters)

It is the constituent which gives to white cast-iron its intensely hard and brittle properties.

PEARLYTE—As has been indicated this substance is not a chemical compound. It consists of an intimate mixture of Ferrite and Cementite. There is ample justification for classifying this mixture as a structural unit. It is so intimate that a magnification of over 300 diameters is required to resolve it into its constituents, moreover the proportion of constituents present is always the same. The dark portions of Fig. II are Pearlyte. Under a magnification of 800 diameters they would be resolved into alternate light and dark laminæ of Cementite and Ferrite, each band being as thin as 0.0001 of an inch. This banded structure gives the substance a beautiful "mother of pearl" appearance when viewed under oblique illumination, hence the name.

This peculiar intimate mixture or combination of two constituents, necessitating its classification as a single substance, is found in the case of other metals as well as with iron and Carbide of Iron. They are known as eutectic alloys. Fig. IV shows a 15% Antimony, 85% Tin alloy. The dark background shows a eutectic alloy of antimony and tin.

All annealed steels contain Pearlyte, either associated with free Ferrite or with free Cementite, never with both. Carbonless iron of course contains only Ferrite. In steels of less than 0.80% Carbon, all the Carbide of Iron, Fe_3C, present combines with some of the pure iron to

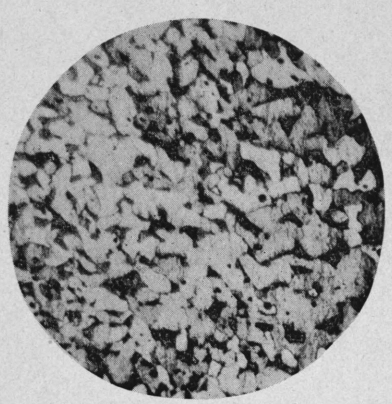


Fig. V. Carbon Steel (0.22%) Annealed and After Forging. (200 Diameters.)

form Pearlyte. The combination takes place in the ratio of 12% Ferrite and 88% Cementite. Hence a steel containing 0.80% Carbon would be wholly Pearlyte. Above this percentage free Cementite will be found, below this free Ferrite. The presence of other impurities raises this saturation point somewhat, and in commercial steels the limit is nearer 0.90% than 0.80%. The size and arrangement of the crystals of Pearlyte depend to a great extent upon the amount of work which has been done upon the metal while cooling. Figs. II and V are micrographs of the same piece of steel, Fig. II representing the structure of the metal as cast, and Fig. V. a portion of the same piece forged down from one-inch square to one-half inch by five-eighths inch. It may easily be seen that the physical properties of these two pieces of metal might be as widely different as their structure, although the Carbon content is practically the same in both cases.

MARTENSITE—This substance may be said to hold a relation to quenched steel corresponding to Pearlyte in annealed steel. Chemically it consists of Carbon and Iron, although, unlike Pearlyte, in varying proportions. It is that constituent which confers hardness upon quenched steel. When Martensite contains the greatest portion of iron it is relatively soft, while with a large percentage of Carbon it is intensely hard, though never as hard as Cementite. Some observers find indications that Martensite is made up of two components of different hardness, but as yet, all efforts to resolve them definitely have failed.

There is a definite temperature or critical point at which Martensite is formed, about 650° Centigrade, differing to some extent in different steels. When a steel has been quenched from a temperature above this point, the Martensite has no opportunity to change into Pearlyte or whatever the case may be, and is thus found in the cooled specimen. In low Carbon steels quenched from above the central temperature Martensite is found associated with Ferrite. In Fig. VI the

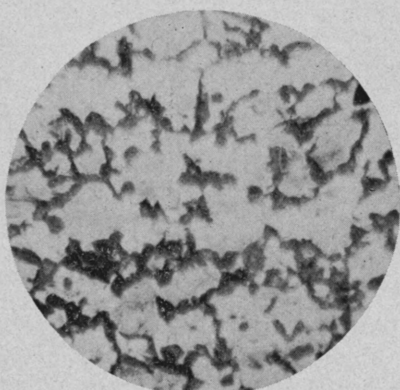


Fig VI. Network of Martensite, Light Nucleus of Ferrite. (200 Diameters.)

dark network consists of Martensite, the light nucleus of Ferrite. In high Carbon steels Cementite is found along with Martensite. The exact nature of the substance is not known. It is connected directly with the question of the hardening of steel, and all hypotheses which seek to explain this phenomena have as their basis an explanation of the composition of Martensite.

Besides the compounds of Carbon and iron already mentioned, free graphitic Carbon plays of course an important part as an element of structure, especially in grey cast iron.

The study of these structural elements in iron and steel has already thrown valuable light upon the physics of these products. There are many more which have been less definitely isolated, and about this many more are yet to be discovered. Nothing has been said of the presence of Manganese, Silicon, Phosphorus, and Sulphur, only because they have not, as yet, been so thoroughly studied in their structural relations as Carbon.

TESTING LABRATORY, General Electric Co.

ALUMNI NOTES.

ALUMNI ASSOCIATION.

President . . . . John B. Peddle, '88, Terre Haute
Vice President . . . . J. David Ingle, '97, Oakland City
Secretary and Treasurer . . . . . John B. Aikman, '87, Terre Haute
Executive Committee—H. W. Foltz, '86, Indianapolis, Chairman; Robert L. McCormick, '96, Terre Haute; Victor K. Hendricks, '89, Terre Haute.

Ned Kidder, '98, is spending the winter in Rockledge, Florida.

Taro Tsuji, '90, is at present working on plans for some electric railways which are to be constructed in Japan for that government.

W. R. McKeen, Jr., '89, who, before associated with Prox & Brinkman, of this city, was with the T. H. & I. R. R., has again entered into railroad service. He is at present with the Union Pacific R. R. Two positions on this road were open to him and it is said that of Assistant Superintendent of Motive Power was the one he expected to accept.

The Class of '96 has just published its "Class News Letter No. 3." It contains letters from eighteen members of the class. These letters were mimeographed and a copy of the whole sent to each member. It is interesting reading, especially as showing the varied lines of activity into which the men of one class have gone in a little over two years. Following are a few notes from the letter:

W. E. Burk reports his duties very congenial in his new position as instructor in chemistry in the Louisville Male High School.

W. L. Decker has left the Sprague Elevator Co. and is with the Elevator Supply and Repair Co., of New York. He mentions witnessing the glorious sight of the parade of battle ships on their return from Santiago.

James Farrington says business prospects are good at the Ohio Steel Co., Youngstown, Ohio. The company is putting in a $2,000,000 blast furnace with electric power plant.

E. B. Harris is delighted with his position as chemist for the Eastman Kodak Co., Rochester, N. Y. He is in charge of all analytical and experimental work conducted in the large laboratory.

P. W. Klinger and family suffered from the high water last spring, being driven from their home by a break in the levee. "Pete" sends regards from "Miss Klinger."

W. J. Klinger is making the "best flour on earth" at Greenville, Ohio.

H. H. Meadows writes from Atlanta, Ga., that the South is on the verge of a great boom.

C. M. Ridgely says, "I am still managing the circulation of the *Galesburg Evening Mail* and forgetting what I learned in school."

A letter from C. A. Sanborn, father of W. R. Sanborn tells that the latter is on Indian River near Dawson, N. W. Ter. He is founder and city Engineer (?) of Bed Rock City which has four houses and eleven inhabitants. He intends to remain there all winter.

Edward Walser is traveling through the "boulder district" of the west installing and starting gold reduction mills.

Geo. E. Wells is with the Wagner Electric Manufacturing Co. of St. Louis, in the Engineering Department.

DePauw vs. Rose.

OUR team more than redeemed themselves by their quick, scientific playing which resulted in the complete defeat of DePauw on Thanksgiving day. The day was all that could be desired, the air just cool enough to invigorate and cause a feeling of exhilaration to creep over the system. The men were all inspired to do their best and if possible prevent their antagonists from carrying off the laurels of victory. Both teams had trained hard and both were confident of winning. Little did DePauw dream of the surprise in store for her, and a surprise it certainly was, for our highest hopes were realized and the team's cup of happiness complete when the game was finished with a score of 26–0 in favor of R. P. I.

The attendance was most gratifying and the enthusiastic audience no doubt helped in a measure to win the game. DePauw rooters were however in evidence and whenever occasion demanded gave vent to their enthusiasm in rousing cheers and applause.

The game started with Rose in the southern half of the field. Ellis kicked off for DePauw to Meriwether, who advanced the ball 15 yards before being downed. Short gains were made through the line by a series of quick plays and Glenn was sent around the end for a gain of 15 yards. The interference was fine and it seemed almost impossible to break it up. Huthsteiner, Meriwether and McLellan bucked the line for gains aggregating 11 yards. The ball was given to Stone who made a brilliant end run of 10 yards. Glenn made 4 yards and Huthsteiner 3 yards through the line. The ball was given to Glenn who carried it across the line making the first touch down. DePauw lost the ball on the kick off and never regained it. Stone failed to kick goal, making the score R. P. I. 5, DePauw 0.

Ellis kicked to Meriwether on the 25-yard-line. The ball was advanced a short distance and lost to DePauw. DePauw however could not keep the ball and Rose immediately started a series of line plays which advanced the ball 8 yards. Davis broke through the line for 3 yards, but was injured and had to retire from the game, Tallmadge taking his place at right tackle. Huthsteiner was sent through the line for a short gain, then Stone tried to advance the ball but failed. Likert made a short gain, Glenn made 5 yards and Meriwether 3 yards through the line. Then our invulnerable "Teddy" Thompson went crashing through DePauw's line for 7 yards before he was downed. A DePauw player snatched the ball but it was returned to Rose. Meriwether made 5 yards through the line and then Huthsteiner was placed in the center of a revolving wedge and the ball carried 8 yards down the field. Here McLellan, aided by fine interference, especially by Meriwether, advanced the ball 12 yards. Stone and Likert made good gains around the ends and the backs broke through the line repeatedly for short gains. Glenn carried the ball over the line for the second touch down. No goal. Score, R. P. I. 10, DePauw 0.

Ellis again kicked to Meriwether on the 25-yard-line. He failed to advance the ball. During this part of the game the backs broke through the line at will and Likert, McLellan and Stone carried the ball around the ends whenever called on. Likert did some especially fine playing. Rose was never in danger of losing the ball on downs and fumbling was unknown, Jumper handling the ball with natural skill and rapidity. McLellan made a good gain and carried the ball over the line. Stone attempted a difficult goal but failed. Score, R. P. I. 15, DePauw 0.

Thompson caught the ball on the 35-yard-line but failed to advance it. The backs bucked the line for short gains and McLellan made 6 yards. Meriwether made one of the prettiest punts of the season sending the pig-skin down the field 50 yards. Time was almost up and Ellis punted 40 yards to Meriwether, who returned it 15 yards. Ellis again punted to Meriwether who was downed before he could return the ball. Huthsteiner was sent through the line for a short gain and time was called. Score, R. P. I. 15, DePauw 0.

Stone kicked to DePauw's 30-yard-line. DePauw lost 3 yards on a fumble and Ellis punted to Meriwether who carried the ball 5 yards before being downed. The ball was advanced 20 yards and then lost to DePauw. The DePauw backs did good work and made several long end runs but were finally held and Ellis kicked to Meriwether who advanced the ball 4 yards. The Rose backs made repeated short gains through the line and followed them up with 10 and 15 yard end runs. McLellan made 8 yards around the end and Huthsteiner made a touch down. No goal, Score R. P. I. 20, DePauw 0.

Glenn caught the ball on Rose's 25-yard-line and made 40 yards before being downed. Cheered on by the crowd Rose carried the ball swiftly up the field and Huthsteiner made another touch down. Stone kicked goal, score R. P. I. 26, DePauw 0.

It was getting rather dark and both sides indulged in punting, Ellis doing good work for DePauw and Meriwether returning punts for Rose. Time was called with the ball near the center of the field and in possession of Rose.

The men lined up as follows :

R. P. I.	POSITION.	D. P. U
Appleton	center	Swaklen
Peker	right guard	Pierson
Thompson	left guard	Ivy
Davis. Tallmadge,	right tackle	Blakely
McLellan	left tackle	Ellis
Stone	right end	Peterson
Likert	left end	Neely
Jumper	quarter back	Rudy-Haynes
Huthsteiner	right half	Davis
Glenn	left half	Haynes-Kuykendall
Meriwether	full back	Priddy

Touch downs: Glenn (2), Huthsteiner (2), McLellan. Goals: Stone (1.) Umpire: Gerber of Purdue. Referee, Coffeen of the University of Illinois.

OUR FOOTBALL TEAM.

Considering the fact that it is impossible for our team to have regular practice hours and also the limited supply of men we have to draw from, we have made a most creditable showing, winning two and losing two games. The team won the last two games played and from this and the general showing made we have good reason to believe that if the team had had the necessary practice and coaching it could easily have won the two games which were lost.

Capt. Davis has played the good game which we have learned to expect from him and has showed excellent judgment in placing his men in positions for which they were best suited.

Meriwether in his usual position back of the line has without doubt played the best game of any member of the team. In bucking the line he is without an equal, never failing to make a gain when necessary. When it comes to punting he is a second Herschberger and in tackling he is one of the best, seldom letting a man pass him.

In Glenn and Huthsteiner, the team has two of the best half backs in the State ; both are swift, heavy, quick and hard players, as was evidenced by the manner in which they tore through DePauw's line in the last game.

Jumper at quarter has played a fine game. He is cool and steady and has all the requisites of a good quarter back.

Kittredge has not played at his accustomed place back of the line but as right guard he has been very successful. He understands the game and is a good man in any position.

Instead of center, Thompson has played left guard and has made as good a showing as he did last year. Teddy never says a word but just "saws wood;" he is in every play and has weight and activity combined.

Appleton at center and Peker at guard have both made excellent men for their respective positions. Both are new and will no doubt be on next year's team.

McLellan at tackle has put up an excellent game and his bulky form could be seen in the midst of every scrimmage. He certainly deserves credit for the way he conducted himself in the Thanksgiving game.

Likert is a prodigy. This is his Senior year and he has never been able to get on the team until this Fall, when he came out and took last year's crack player's place at end. We would have missed Austin much more had his place not been so competently filled by Likert.

Stone in his accustomed place at end has proved himself the possessor of all the qualifications of a successful end.

The team has been favored this year with an abundance of good subs and several of them will secure positions on next year's team. Tallmadge made a very creditable showing in the Thanksgiving game.

We will lose by graduation six out of the eleven but if next year's Freshman class is as profuse with players as is the present Freshman class we will no doubt be able to collect eleven men capable of representing us on the gridiron.

Manager Edwards has done his best to make the team a financial success and would have succeeded beyond doubt had not the inclemency of the weather at the Louisville game prevented a large audience. He is to be praised however for his efforts.

THE ATHLETIC ASSOCIATION AND THE GYMNASIUM.

In the spring of 1895 the Athletic Association of the Institute became thoroughly impressed with the crying need of a substantial, commodious gymnasium building upon the campus. A subscription fund was started among students and alumni, which met with a most enthusiastic response. The Board of Managers, seeing this strong sentiment backed by subscriptions that were to many a student's pocket-book a considerable sum, generously offered assistance. The result needs no lengthy comment to any one at present connected with the Institute. The splendid brick building, well adapted for its purpose, large, conveniently arranged and abundantly lighted as to interior, and graceful in exterior design, is a constant reminder of the entire success of the enterprise. It is a monument to a hearty belief in the value of physical training on the part of alumni, students and friends of the Institute.

With the building erected and completed, however, another problem arose. How should it be used, or by what plan could the students as a whole reap the greatest benefit from the gift? This problem has only been partially solved in the past. The faculty committee on athletics have been carefully considering the matter for some time in the hope of being able to aid the Athletic Association, and through it the students, to a successful solution.

The situation may be briefly stated thus : Outdoor sports and games, as at present conducted, occupy fully the fall and spring terms. This leaves the winter term as the period in which the gymnasium will naturally be used most and can be made of most benefit. Two facts are patent to any one who will study the subject carefully. First that a gymnasium without an instructor is of about as much value to the average man as a school without a teacher. Second, that while much good work in training and building up of the body can be done with little special apparatus, yet a reasonably complete equipment of standard forms of apparatus increases the possibilities many fold and adds much of spice and interest to the work. The Board of Managers recognizing this, appropriated a considerable sum from the funds of of the Institute for the purchase of some valuable pieces which have been placed in our gymnasium. Others have been designed here and made in the shops. These are perhaps sufficient for the present. Many other things easily suggest themselves however which could be added with great benefit.

The following plan is now submitted as one promising best results under present conditions. Let the regular fee of one dollar per term be collected by the Institute from all students. No further dues or fees to be collected by the Athletic Association. Of the total amount collected, one-third to be expended by the Association for the conducting of out-door games and sports during the Fall and Spring terms. The remaining two-thirds to be expended for the maintenance of the gymnasium and for special instruction in the Winter term.

All students would thus become members of the Athletic Association and entitled without question to all its privileges. The relation which the members of the Association sustain to the gymnasium, which has heretofore been difficult to decide, would be perfectly clear.

Should this plan meet with the approval of the students generally, in whose interest it is proposed, it will be further perfected in detail by the Athletic Directors and put into effect with the beginning of next term.

A. S. HATHAWAY,
R. L. MCCORMICK,
O. E. MCMEANS,
Committee on Athletics.

ATHLETIC NOTES.

The hand ball and basket ball fiends are practicing regularly in the gymnasium and we hope before long to be able to announce a hand ball tournament and several basket ball games between the respective classes. There is certainly material in the school for several good teams and much healthy sport could be derived from a series of basket ball games.

What the Athletic Association needs more than any thing else just at present is for every one in the school to pay his dues. It is the duty of the athletic directors to collect these dues, which every student should pay willingly.

Stone and Huthsteiner have been appointed a committee to revise the constitution and by-laws of the Athletic Association. When completed a type written copy of the constitution with proposed changes will be posted on the bulletin board and each member will be given a chance to express his opinion and to suggest any further changes which may be desirable.

THE ALL INDIANA TEAM.

In choosing the All Indiana Team for 1898, coach A. P. Jamison of Purdue University, has selected a number of men who well deserve to be recognized as the champions of the state.

The team is largely composed of Purdue men although Rose Tech holds two places, Stone as one of the ends and Meriwether as the full back.

The team is as follows:

Center, Eggman Purdue; guards, Sparks, Indiana University, and Webber, Purdue; tackles, Herbold and Robinson, Purdue; ends, Stone, Rose Tech, and Raub, Purdue; half backs, Byers, Purdue and Yeutsler, Indiana University; full back, Meriwether, Rose Tech; quarter back and captain, Sears, Purdue.

Grant and his assistant have been busy for some time cleaning up the gym and getting things ready for the regular class work which will begin at the opening of next term.

Surveying by Photographic Methods.

ARTHUR D. KIDDER,' 99.

THE object of any survey is to determine the complete location of points below, on, or above the earth's surface. Such data is taken in the field as will suffice to plot these points to scale on a map showing the horizontal projection of each point with an added reference indicating its elevation above or below a datum plane, or with a separate map showing the vertical projection of each point. In every case a "base" is required. It may consist of any number of points, from two up, whose locations are accurately known. An initial base of two points whose horizontal distance apart and "bearing" are known, comprises the simplest case, and such two points are always the beginning of a more extended base. The bearing gives the azimuth or the angular position of any line with respect to the local earth's meridian. It is an unnecessary feature of a purely relative map. The bearing of the initial base may be determined by an observation on the north star, on the sun, or by means of a magnetic needle.

From the given base all subsequent points are found by horizontal "triangulation"; a triangle is fixed, (1) when two angles and the included side are known; (2) by two sides and the included angle; or (3) by the lengths of the three sides. One of the three determinations is always necessary to locate any point in a survey. The first case will, in general, be employed in the present discussion. The elevation of any point with respect to a horizontal datum plane is usually determined by the method of "leveling," but can be found by triangulation in a vertical plane, case one will again be employed with the modification that one of the known angles is to be a right angle.

With this rather elementary statement of the problem before us, we can proceed to demonstrate that all the necessary elements are present in perspective and can be deduced in a simple manner when we have *two separate* and *vertically projected views* of an object, such as can be obtained with any camera fitted with vertical and horizontal cross-hairs intersecting in the principal axis of the lens, and means for leveling the instrument.

The basis for the deduction from a perspective view is, that all visual rays connecting points in the landscape and projected upon a vertical plate pass through a single point. For convenience this point will be taken as the aperture of a "pin hole" camera giving the same view. The image thus formed is exactly similar to the view presented to the eye of the observer placed at the aperture and looking along the principal axis of the instrument. Referring to Fig. I, A, B, C are points in a landscape, a, b, c their images; the aperture is O. The horizontal cross-hair HH' determines the horizon of the view, the vertical cross-hair VV' intersects HH' at P and OP is

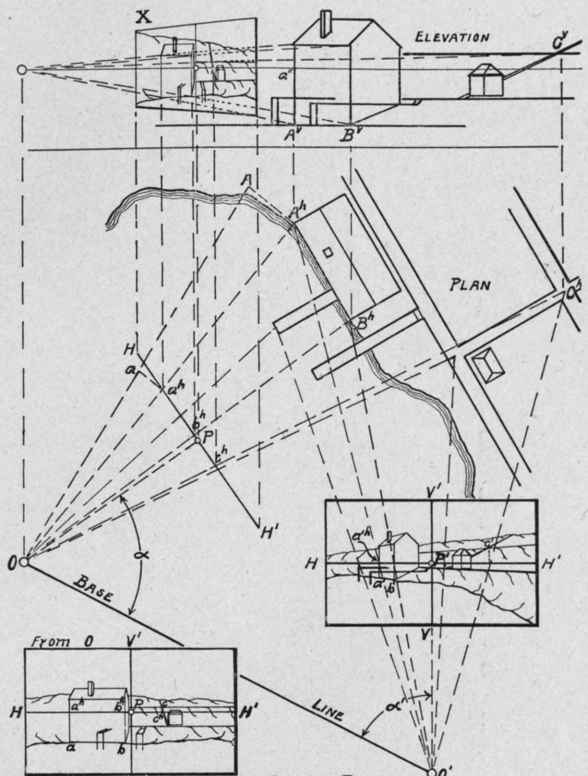


FIGURE I.

the principal axis. The points are shown in plan in A^h, B^h, C^h, a^h, b^h, c^h, O, HH', and P. The horizontal angle at O between the principal axis and A, is $a^h O P$, whose

$$tangent = \frac{a^h P}{O P};$$

the angle of inclination at O between A and the horizon is $a O a^h$, whose

$$tangent = \frac{a a^h}{O a^h}.$$

In the field the camera is stationed with the aperture directly above one station, O, of the base line, and leveled. The angle α must then be determined between the base and the line of sight; the simplest way without the use of extra instruments will be to set a stake visible on the ground glass and cut by the vertical cross-hair; the distance from O to the stake and from any other known point on $O O'$ to the stake will be sufficient to plot the angle. The exposure is made and recorded, and a similar operation is performed at O'. The prints from two such views furnish the data for the location of every point visible in the two views that can be identified. The map is made by plotting the base $O O'$ to any desired scale, and laying off the two lines of sight $O P$ and $O'P'$. The length $O P$ is the focal distance of the lens used and is laid off in actual dimensions; HH' is drawn at right angles to $O P$ and on it the points a^h, b^h, c^h are located from scaling the view. A^h lies along $O a^h$ somewhere; it lies also in the line $O' a'^h$ as similarly constructed. The intersection of the two lines is evidently the location of the point A^h. The plan map, point by point, is thus rapidly developed. The distance $a a^h$ is scaled on the view between the image a and its horizontal projection a^h, this distance being laid off at right angles to $O a^h$; the line $O a$ can be drawn and its intersection with $A^h A$, which is parallel to $a^h a$, gives the distance $A^h A$ to the scale of the drawing of the height of A above or below the horizon. If desired this distance can now be laid off below the horizon in the upper part of the figure as shown $a'' A^v$, and a vertical projection of the landscape is thus quickly constructed. It might be stated to avoid confusion that the view, X, is not the view as seen from O, nor a projection of this view revolved; it is introduced to aid the eye, and dimensions on it are only indirectly related to the dimensions of the picture. The view as seen from O is shown below.

THE CAMERA.

A plain, rectangular, bellows camera, firmly constructed and mounted on a firm tripod is the simplest and best for surveying purposes. A rising and falling front will be found very convenient; an ordinary three or four screw leveling head is indispensable for extended work, and a pair of level bubbles is needed. The objective lens should be free from spherical and chromatic aberration and free from distortion; a lens of the standard of the Dallmeyer Rapid Rectilinear can be depended upon.

The first essential, peculiar to this work, is the pair of cross-hairs. A thin frame to carry the cross-hairs can be constructed to fit just in front of the ground glass; with this frame in position and the camera leveled, take a small carpenter's level and mark with a knife the vertical and horizontal lines, passing through the intersection of the diagonals of the frame. Through each pair of slits stretch the finest single strand of silk thread obtainable and fasten the ends with wax or a small tack. If carefully done the vertical cross-hair is finished and one adjustment remains for the horizontal cross-hair.

The determination of the constants of the instrument can now be made in the field by making one view for "register." Three measurements are needed, and upon which the accuracy of all future work is based:

I. *The Measurement of OP, or the Equivalent Focal Distance.*

II. *The Determination of HH' for any View.*

III. *The Measurement of the Field of View.*

I. As stated before, the real focal distance of the lens is not desired, but an equivalent focal distance and equal to the distance from the aperture of a "pin hole" camera to a plate giving the same *sized* image as the image in our camera, is the desired constant.

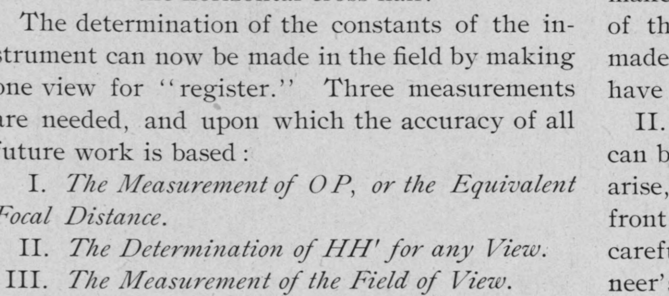


FIGURE II.

Let the camera be leveled and focused on an object, A, at a distance of 150′-200′ from the objective O. (See Fig. II). Let the vertical cross-hair cut A and set a second flag, B, at right angles to OA, so that its image, b, is about one-half way between VV′ and the edge of the ground glass. Measure OA^h and A^hB^h and make an exposure; from a finished print scale b^hP, then

$$OP = \frac{OA^h \times b^hP}{A^hB^h}$$

Other methods for measurement of OP are by means of optical measurements directly upon the lens, but these do not take into consideration the shrinking or stretching of the film and print. By the method outlined the distance, b^hP, is measured on the working print and the equivalent focal distance forming the basis of the map construction is evidently obtained. With a good lens and a small stop or aperture, distortion in the picture will be extremely small. When the camera is focused upon the distant object it is well to make some kind of a mark to indicate the position of the ground glass and subsequent exposures made with the ground glass in this position will have the calculated equivalent focal distance.

II. The determination of the horizon, HH', can be made at the same time as (I). Two cases arise, (*a*) the camera having a rising and falling front, (*b*) fixed objective. (*a*) With the camera carefully leveled and focused, employ an engineer's level to set a target on the distant object at the same elevation as the horizontal cross-hair of the camera. Raise or lower the objective of the camera until the image of the target is cut by the horizontal cross-hair. Make a mark upon the vertical standards showing the position of the objective; the horizontal cross-hair coincides with the true horizon whenever the objective occupies this position. In raising or lowering the objective from this position, HH' will be above or below the image of the horizontal cross-hair by the same amount. A scale on the objective standard is very convenient, and a record of the position of the objective must be made with each exposure. It is evident that with a rising and falling front a hillside or valley can be brought into better position. (*b*) If the objective be immovable, the true horizon can be determined from the horizontal cross-hair as a reference line. With the camera leveled and focused, set a target on the distant object by means of an engineer's level, at the same elevation as the center of the lens. On the ground glass scale the distance between the image of the target and the horizontal cross-hair, then the horizontal cross-hair can be reset by this amount. It is evident that the center of the lens can not be exactly determined, but it is certain that it can be found within 0.01 of a foot. If the target be set at a distance of 200 feet for the determination, the error in the position for HH' as thus determined may be

$$OP\frac{0.01}{200}$$

or less than 0.00005 of a foot in most cameras; the error in leveling corresponding to this amount will be within the limits of precision expected of the method.

III. Let the distance from the center of a plate to the edge measured along HH' be PH, the angle included in the field of view

$$= 2 tan^{-1}\frac{HP}{OP}.$$

The value of this information is apparent if a complete or partial panorama from one station is to be taken.

A TRIAL.

It was the pleasure of the writer to accompany the '00 and '01 Civils during their encampment at Forest Park, last June, and to undertake a little practice of the methods outlined in brief above. The camera employed was the 5″x8″ instrument belonging to the Civil Department. It was fitted with a Dallmeyer Rapid Rectilinear lens, a rising and falling front, a transit tripod with a four-screw leveling head, level bubbles, and a Gurley compass. The focal distance as determined in the "register" was 10″.8, and the field of view after subtracting an ½″ margin for uncertainty, was found to be 33° 54′. The work attempted was the topography of the hillside extending south from the south bank of Otter Creek along which their "Preliminary" line passed. From the "P" line as a base two instrument points were located about 100′ apart and about 160′ west from the line. At each point three views were taken of the hillside; each set formed a panorama with an angle of 30° between the successive lines of sight, the direction of each line of sight being given by the Gurley compass on the instrument. At each instrument station the elevation of the horizon of the instrument was found by leveling from the "P" line to the instrument. This includes all of the field work and it required about forty-five minutes' time of the operator and one assistant. For the map construction about twenty trees scattered over the hillside furnished points for identification, and the bases of their trunks gave points of elevation on the hillside; between these points five-foot contour lines were interpolated; the view, showing every feature of the surface, aided greatly in the interpolation and plotting. The contour map thus quickly prepared compares very favorably with the contour map as developed by the party in the regular manner.

THE VALUE OF THE METHOD.

Granted that this method does not attain that degree of accuracy required in geodetic surveying, we may nevertheless claim that a very fair degree of precision may be accomplished, and to this may be added that nothing is forgotten, the views take "everything in sight" and aid the eye as no map or set of notes can; the rapidity of the field work is also a very important item. As an auxiliary to other methods it probably attains its greatest usefulness; to those who by chance may be called upon to make a survey without a set of surveyor's instruments at their disposal, the camera so fitted is "the whole outfit."

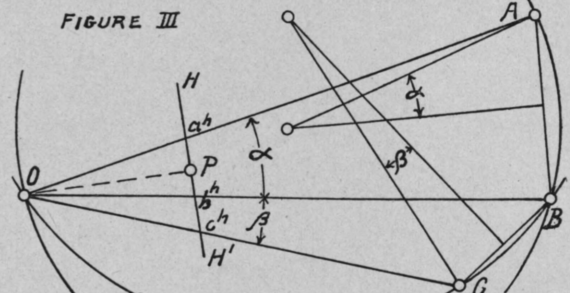
To those who have used the method the explanations here given are doubtless quite superficial; to those who have never before studied the simple principles involved, the demonstrations may perhaps be suggestive; the ingenuity of the chief engineer of a party is frequently called upon to decide among different instruments and methods and combinations; set rules do not exist. When the camera can be combined with other instruments the photographic work can be made more accurate and perhaps carried out more quickly. For instance a transit can be employed to determine the precise location of each instrument point; the error of the method thus being non-accumulative when we pass to succeeding stations; the transit may be employed to determine the elevation of the horizon of each panorama with reference to a common datum, or a level can be used to advantage for the same purpose. One of the most convenient auxiliaries is a 4″ compass placed upon the camera when leveled and serving to obtain the bearing of each line of sight.

For reconnoisance surveys, for work in a rough country, and in places not easily accessible, the camera can be employed to a high degree of usefulness. The chief difficulty encountered in its use in taking topography is in identifying points on the surface of the earth in each of the two views; critical points stand out, however, and these elevations can be plotted; thence interpolating, with the aid of the view for rises and depressions, a respectable contour map can be developed. For hydrographic surveying and in other cases where the position of the operator, taking a sounding or other measurement, is required from visible points as a reference, a "snap shot" and an application of the "three point problem" determines the location. This particular use may replace the sextant or transit as the case may be. In surveys by the camera alone the solution may serve to give the location of the instrument point.

For those readers who are not acquainted with the phraseology, "three point problem," a statement and solution may not be out of place here. Three points, A, B and C, and the angle included between AB and AC are known. (See Fig. III.). As seen from O the angle $AOB=\alpha$, and the angle $BOC=\beta$; required the location of O. From the single view $\alpha=a^h O b^h$, and $\beta=b^h O c^h$, as indicated in the early part of the discussion. The solution may be accomplished either analytically or graphically; as our whole method is essentially graphical this solution will be chosen.

Having plotted A, B and C, lay off complement α at A, and the intersection of this line with the perpendicular erected at the middle point of AB is the center of a circle upon which O lies. The same may be performed upon complement β at C; the intersection of the two circles is evidently the location of O.

FIGURE III



Supposing that the bearing OP had been noted by means of a compass, the solution is considerably simplified; two points A and B and their bearing is a sufficient base. At any place on the drawing board lay off OP, HH' a^h and b^h, OP having its correct bearing. The system of lines is now parallel to the correct position of the system. From A draw a line parallel to Oa^h, and from B one parallel to Ob^h, their intersection determines the correct position for O.

For extended surveying by the camera alone, successive instrument stations must be shown in preceding views so as to be located as a part of the system; the selection of points for stations is one of considerable importance and well worthy of consideration. For the system of elevations by the camera only, the most convenient method is to assume some point in the first view, or even the instrument point itself, as the datum; reference to Fig. I shows that one point decided upon determines all points of elevation. At successive stations measure up from the ground to the horizontal cross-hair; the elevation of the ground at the instrument station having been determined in an earlier view, the new horizon elevation is determined and hence all points in that view. Another very unique application requires the use of but one view; it is for the determination of the outline of a lake or any body of still water. This outline is a contour and every point on it is at the same elevation; let a view be taken of the shore, the bearing OP be noted, and the elevation k of HH' above the surface of the water be measured. Using the nomenclature of Fig. I, let OP and HH' be plotted; for a point A on the shore, A^h lies on Oa^h at a distance from O

$$= \frac{k \times O\,a^h}{a\,a^h}$$

"Bismarck," '01, "Get into the game, Peker. Hurrah for Germany!"

Stevens says "If you dissolve iodine in alcohol you get tincture of arnica."

Professor Wickersham: "You must not talk so much or you will make me tired."

Reflection over the Athletic Association is rather *deep* thought, now that it is "in the hole."

The freshman class seem to have some artistic ability. Perhaps we may hope for a Modulus from them.

Schwable, '99, to Professor Noyes: "Please tell us when you are talking about anything that is familiar to us."

Hand-ball has revived with the cooler weather, and the court in the gymnasium is in use in almost all the vacant hours.

Professor Wagner was absent from the Institute for several days, giving expert testimony in Chicago and Indianapolis.

Likert: "I've tried and tried to read 'The House of the Seven Gables,' and 'Little Men' but I never could appreciate Dickens."

Likert, '99, has entirely recovered from the severely sprained ankle which he received in the DePauw game on Thanksgiving Day.

Professor Hathaway explaining a problem in Calculus at the board and not finding a pointer handy, used an 8-foot window stick to good advantage.

Professors Gray and Peddle are about to begin a series of experiments upon the use of balls in thrust bearings. Special apparatus will have to be made.

A portion of the west railroad gate at 10th and Locust streets has had to be repaired as the result of having suffered a collision with one of the Professors.

Work has already commenced, by the Junior class, on a dividing engine for making the millimeter scales, the marking of which has hitherto been very tedious.

Weatherhead, '01, returned to his home in Cincinnati, the first of the month, and is taking special work in German and Chemistry in the University of Cincinnati.

We are glad to think that the old ladies whom Miller, '01, represented as "running up the hill catching their breath," were fortunate enough to catch it and not merely run after it.

Professor Hathaway, after having walked around the room for about 15 minutes and apparently not realizing that he had a class before him: "You were so still you woke me up."

The patterns for the Universal Grinder, designed by Mr. Harris for the shops, are well along toward completion, but the metal work is being reserved for the Seniors in the Spring term.

The other day Dr. Noyes exchanged "Class excused" for "We will go on with the lecture." The class was so surprised that they were unable to follow his advice before he corrected himself.

A Freshman athletic director, who seems to emulate the "Seven Sutherland Sisters," the other day asked one of his classmates: "Do you think I ought to join the Athletic Association?"

The four Kilowatt, three-phase, alternator designed by Stilz, '98, the patterns for which were made in the wood shop last year, will soon be under way. The four-by-six Duplex pump, is now nearly done.

The third meeting of the Scientific Society was held Tuesday, Nov. 15th, at 11 o'clock. Two papers were presented, Kittredge, '99, upon "The Treatment of Wood to Render Non-Inflammable," and Larson, '00, on "The Injector."

Mr. Harris will soon make experiments on alloys of aluminum and zinc, with a view of making the Bertillion instruments from this, instead of from brass and iron. An alloy nearly as hard as brass can be made, which is of course far lighter.

The lungs of the "student body" had until Thanksgiving day little chance to do honor to the foot-ball team. But here at last the good old yells were given again, the Freshmen reading them from their programs like a choir of nice little boys.

A Junior chemist asked one of the Seniors in the Laboratory what the temperature of boiling water was on the Centigrade scale. He was told 183°. A minute later he came up with beaming face. "That made my results much nearer. I thought it was 100 before."

Butler and Crebs, '99, have nearly cleaned up the floor of the Chemical Laboratory. The vessel in which they are melting sulphur always breaks at the critical moment, and in scraping the hardened cake from the floor they get, incidentally, everything else that is there.

The freshmen in the woodshop are still doing more cabinet-work than pattern-making. That the work has been very varied indeed may be seen from some of the work thus far finished: several tool-chests, a number of fancy tables, three heavy wheel-barrows, and a book case.

Professor Hathaway ought to feel peculiarly safe when riding his wheel. Such a machine ought to have an experience, rich and full enough to be able to guide itself around any obstruction. We are afraid it sometimes goes to sleep, however, especially when it sees a pile of ashes.

One day, a week or two ago, the campus presented a scene of unusual activity. Fully three-fourths of the students were upon the gridion, either looking on with interest or engaged in kicking the three footballs which were kept in constant motion. Such a scene is very encouraging to those interested in the success of the Athletic Association.

The scales ordered for the Civil Department from the Fairbanks Scale Company, have been received and prove extremely delicate. They are designed to be used on the steel model of a draw bridge which was constructed last spring, in determining the stresses in the various members. They will also be used in standardizing indicator springs, by Professor Wagner.

THE TECHNIC offers its sincerest apology to the classes which have erected monuments upon the campus for the typographical error in the November TECHNIC, which records only four in place of six monuments, this being a fault in the typography of the article and not an intended slight on the part of the editors, and should read "Erection of Monuments," Chapter VI.

Every year the Freshman Class has threatened to paint its symbols on the cow that grazes on "Stave Pile Park." Although it has never been done, she seems to have taken the will for the deed. One day just before Thanksgiving, as the men were hurrying to dinner, she made so vicious a dash at the crowded sidewalk that several men almost fell over into the street.

One of the most interesting pieces of work which the Shops have had for some time has been the construction of the measuring instruments for the Bertillion System of measuring criminals. A small pair of calipers, with iron fingers and graduated scale, is intended for measurement of the fingers and joints. A larger pair of similar construction is used for foot and elbow. A pair of brass calipers, with millimeter scale, is to be used for measurements of the head.

Dr. Gray is working out a systematic treatment of the various windings used in dynamo construction which will probably be ready for publication in a short time.

R. W. Scott, ex-'98, made a short visit to his friends and the Institute just before the exams. He is at present city sales agent for the C. and C. Electric Co., New York City.

There will be a large representation of the faculty at the meeting of the Academy of Science and the College Association which will meet in Indianapolis, December 30th to 31st.

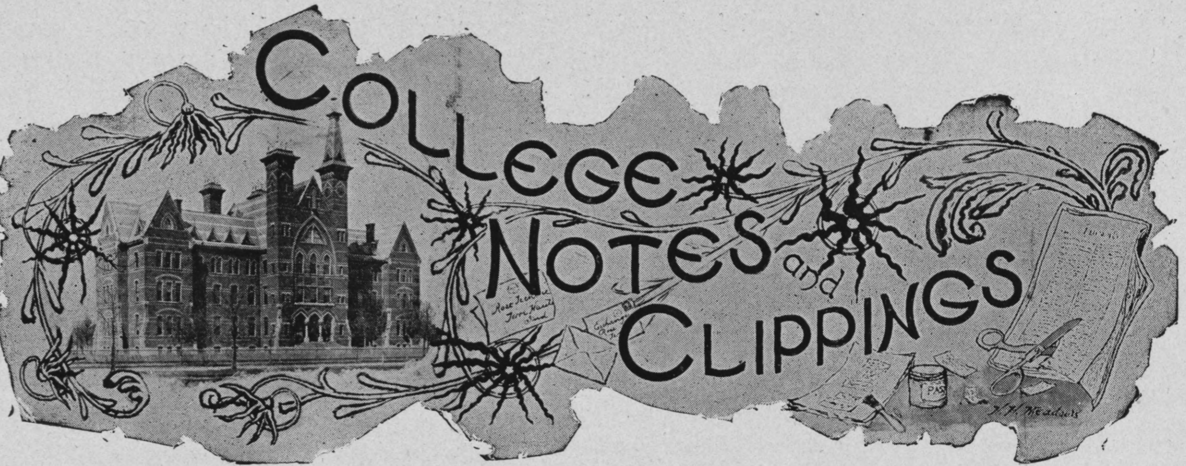
Prof. Hathaway is progressing so rapidly with the work upon the book on Calculus which he is writing that it will most likely be ready for the use of the Freshman class in April.

Dr. Gray has been selected as a member of an International Committee to investigate the properties of iron and formulate a series of tests which shall be standard for the acceptance of structural iron. This committee is composed of a representative from Russia, France, England and America.

Mr. Shepherd went quail hunting about Thanksgiving time and the next day he presented Dr. Noyes with " a case for toxicological examination." Dr. Noyes: " Where will I find the directions?" Mr. Shepherd "Inside the package." Dr. Noyes' laugh was hearty when he opened the package and found a half-dozen dressed quail. He said that they would be analyzed with pleasure.

The *Physical Review* for November contained a paper by Dr. Gray, which he presented before the Boston meeting of the American Society for the Advancement of Science, in Boston last August, upon "The Dielectric Strength of Insulating Materials." Being the results in part of the theses of Meyer and Rypinski of the Class of '97, and Ryder and Schneider of the Class of '98, and from notes taken by Dr. Gray in person.

Those who tarried on the campus for a few minutes after the football game between '99 and the other classes were favored with a rather rare bit of excitement. Attracted by '99's earnest appeals for aid, during the latter part of the game, a rabbit came bouncing over the campus. His presence was soon discovered and a lively chase followed. In a few minutes, however, the rabbit showed his superior tactics by dodging fifteen or twenty fellows and making his escape through the front fence.



The Carlisle Indians cleared $20,000 on their foot-ball games in 1897.

In giving the score of the foot-ball game between University of Chicago and Beloit College, the Chicago *Times Herald* puts it as follows: Herschberger 15, Beloit 0.—*Lombard Review*.

The *Technologian* has been received and now comes weekly to take the place of the monthly "*Georgia Tech*." It is to be hoped that this management will fare better than the last one and that we will receive the *Technologian* regularly.

Since October the 29th, class rushes are not popular at Franklin and the faculty has decided that any student or students, who shall either make or accept any challenge that would lead to such affairs, shall be subject to discipline ranging from reprimand to expulsion.

The *Yale Scientific Monthly* has two exceptionally interesting articles. "The Submarine Boat" and "A New Application of the Electric Arc." In the latter a number of practical uses of the arc are cited, such as drilling armor plate, blacksmith forges, electric welding, etc.

The *American Machinist* has been giving some space to letters pertaining to three point ball bearings and some of the conditions set forth are rather startling. It hardly seems possible that two points on a ball can roll as elements of a cone and the third point as an element of a cylinder and still eliminate sliding contact.

There is quite a little talk of abolishing the goal-kick, and it is probable that it will be done. Except in special cases a team can only get a touch down by reason of merit of some sort and it seems hardly fair to give a weaker team a chance to win the game through the kindly influence of wind, a muddy ball or any of those trifles upon which a goal-kick depends.

Mr. Hugh H. Taneway, a former guard of Princeton, in the *New York Sun* makes up the All American foot ball team for 1898, as follows: Ends, Palmer of Princeton and Hallowell of Harvard; tackles, Hillebrand of Princeton and Chamberlain of Yale; guards, Brown of Yale and Hare of Pennsylvania; center, Overfield of Pennsylvania; quarter-back, Daly of Harvard; half-backs, Dibblee of Harvard and Durston of Yale; full-back, Romeyn of West Point.

We received this month No. 2 of Vol. III of the *College Athlete*. The only objection to the "*Athlete*" is that it does not come often enough. The "*Athlete*" is a strong promulgation of

"College games
on
College grounds
by
College men
for
College men,"

and should be in the hands of every college man who desires to make college games, contests between gentlemen and not tainted with any odors of the prize ring.